Chapter 4
Structured Analysis and Functional Architecture Design

Dr. Eng. Shady Aly

Modeling IIS

- This is the first step in the design of IIS for an industrial enterprise.

- The design proceeds from a definition of a business model of the enterprise. This business model (IS model) is a description of
  - the functions of the business,
  - the data requirements, and
  - the interactions between the functions and data requirements.

- **Functional or activity architecture** describes a conceptual model of the activities that operate the business and the relationships between those activities.

Modeling IIS

- The word **architecture** denotes the fact that the model has a **layered structure** مكون من طبقات

- A related conceptual model of the firm is the **informational or data architecture.** This is a model of the information requirements needed to perform the functions of the business.

Modeling IIS

- There are three layers of system design to consider in an information system project: conceptual, implementation and execution

- The conceptual layer consists of the logical design of function and data requirements

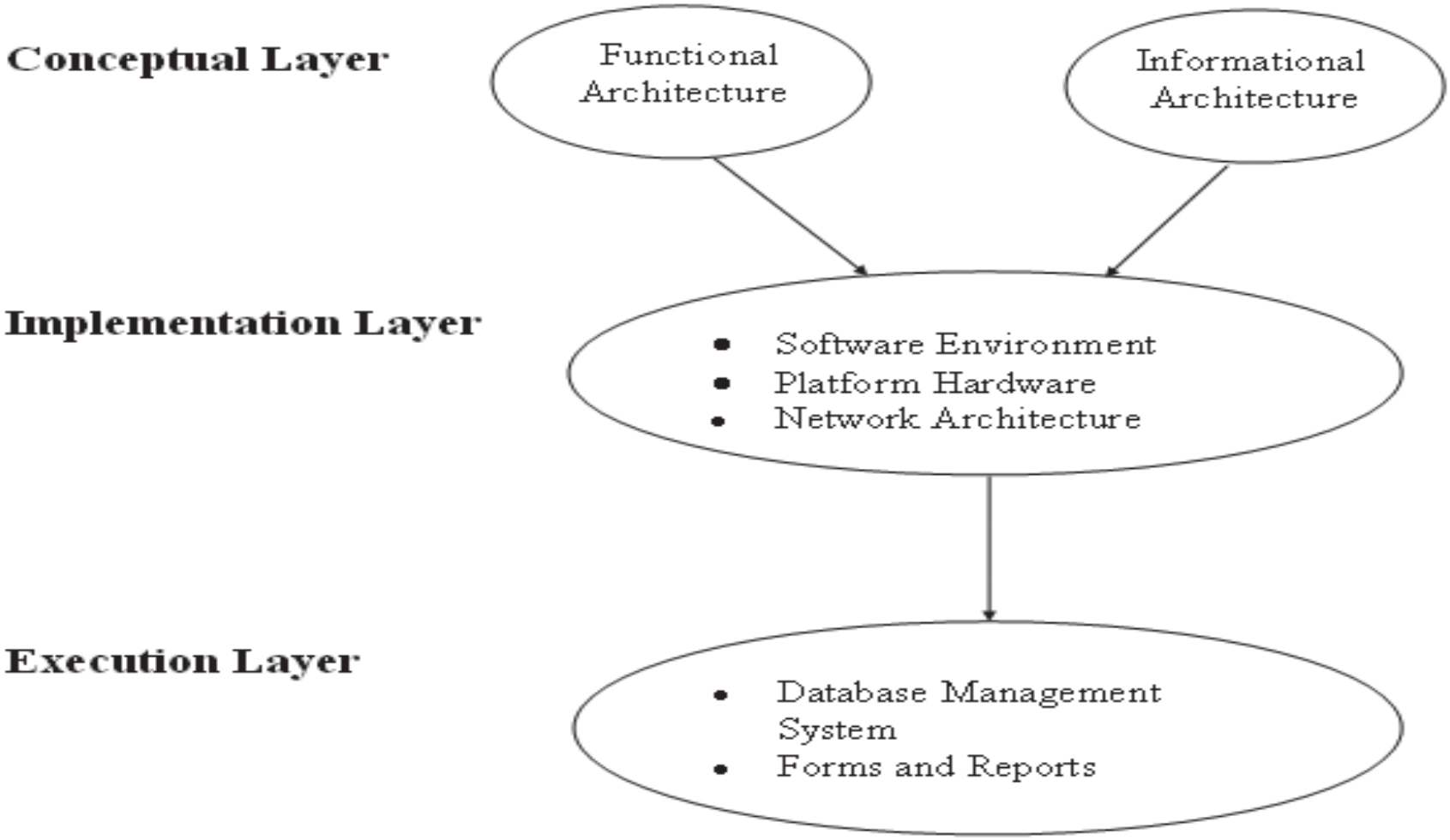
- When a conceptual design is complete, the next step is to implement the blueprint in hardware and software. This is the implementation layer that requires the selection of a database management system, hardware platforms, and a communication medium.

Modeling IIS

- At the execution layer, the conceptual model and implementation techniques are coded in **software** in terms of forms and reports

- The forms and reports are used to interface with the individuals performing the functions defined in the functional architecture.

Layers of the information system design process



Functional modeling

Integrated computer-aided manufacturing definition 0 (IDEF0)

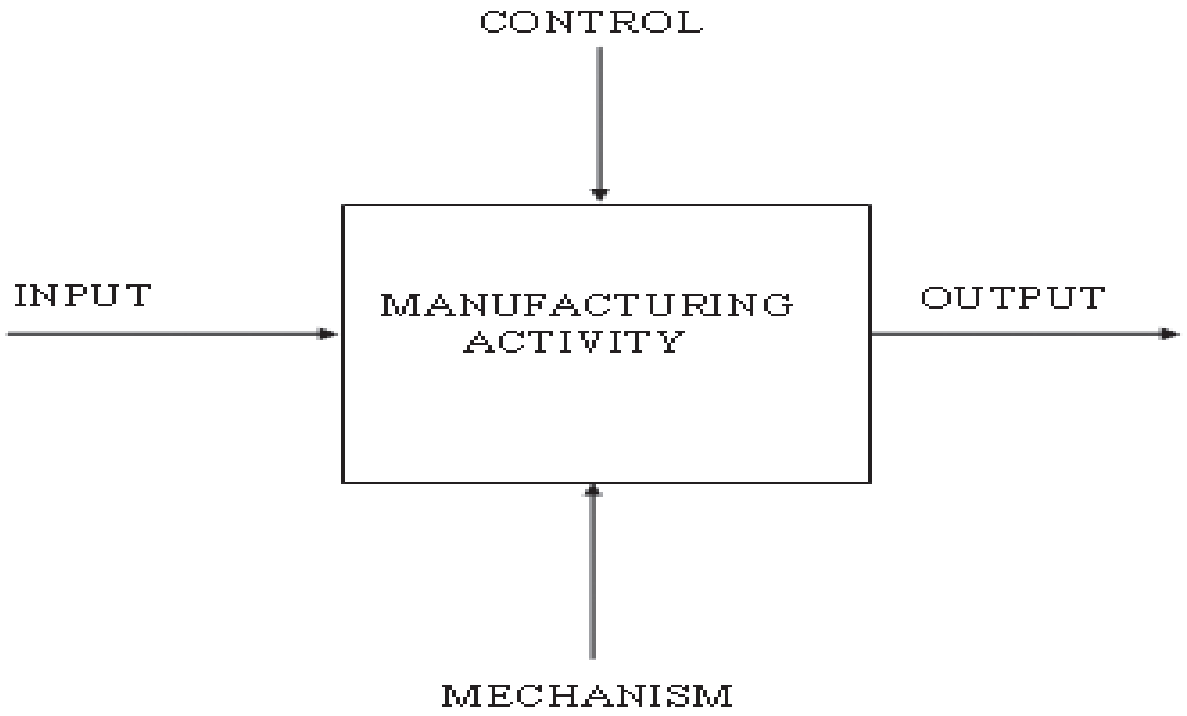
IDEF0
Methodology modeling primitives

- **IDEF0 (integrated computer-aided manufacturing definition 0**) is a modeling methodology for designing and documenting hierarchic, layered, modular systems.

- The **activity box is used to describe a function being performed** in the enterprise.

- Function can be either a material conversion function (machining a part), or an information conversion function (processing a requisition for ordering materials)

IDEF0 activity box and connecting arrows



IDEF0 activity

- **Inputs** are those things that are transformed by the function (a work piece to be machined, or an requisition information to be transformed into a purchase order

- **Outputs** are the result of the transformation process provided by the activity (finished component after machining, or a purchase order)

IDEF0 activity

- **Mechanisms** are the means by which a function is realized

- The mechanism in the material conversion of a work-piece to a finished component might require a lathe and lathe operator as mechanisms

- The information conversion to process a requisition into a purchase order could involve a purchasing agent as the mechanism.

IDEF0 activity

- A **control** is a condition or set of conditions that guide or constrain (ترشد أو تقيد) the performance of the activity

- For example, the machining activity may require a numerical control parts program. An example of information conversion, the requisition processing function may require adherence to a set of company rules or purchasing policy (e.g., purchasing only from approved vendors).

IDEF0 activity

- The activity box and four arcs provide a concise expression: an **input** is transformed into an **output** by an activity (function) performed by a **mechanism** and governed (يتحكم بها) by a **control**.

- The specific activity, inputs, outputs, mechanisms, and controls are defined by the **situation** being modeled.

IDEF0 activity

- Grammatical convention used in naming activities and arcs.
- Activities represent actions being performed and are labeled with verb phrases أفعال.
- Inputs, outputs, mechanisms, and controls represent things and are labeled with noun phrases أسماء.

IDEF0 Hierarchic decomposition
التحليل التسلسي الهرمي

- IDEF0 is a top-down modeling approach

(نمذجة متسلسلة من الوظائف الرئيسية إلى الوظائف الجزئية)

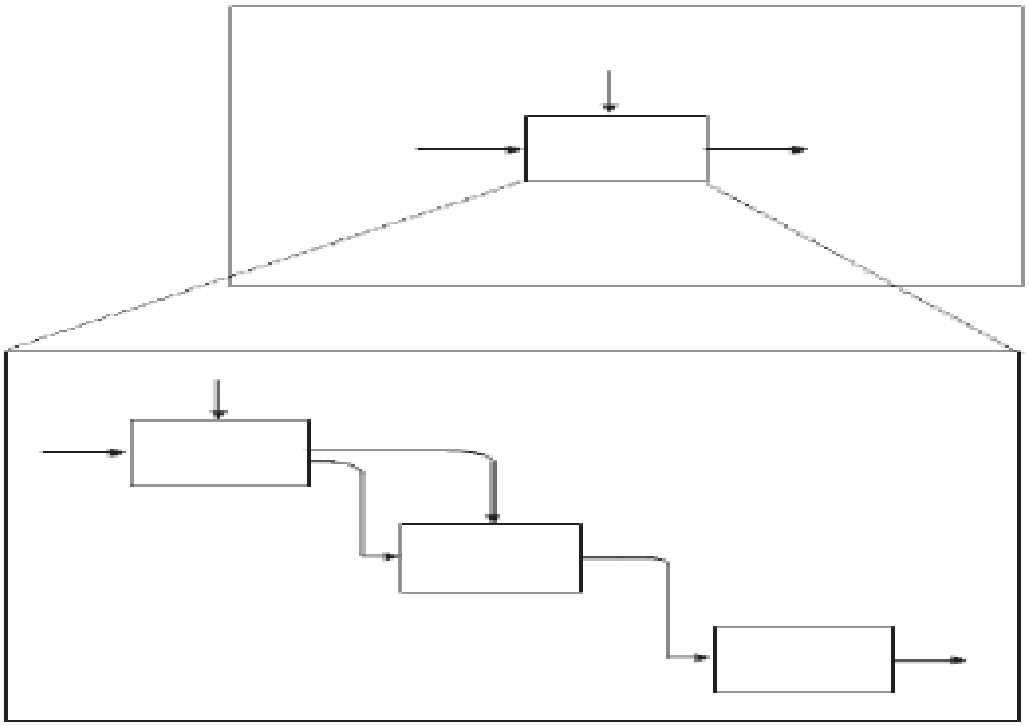
- The first layer is a single activity box that describes the overall function of the enterprise, organization, or process within the enterprise that is the subject of the model

- This overall activity is then decomposed تحلل أو تفكك إلى into its major sub-activities الأنشطة الجزئية الأولية at the second layer

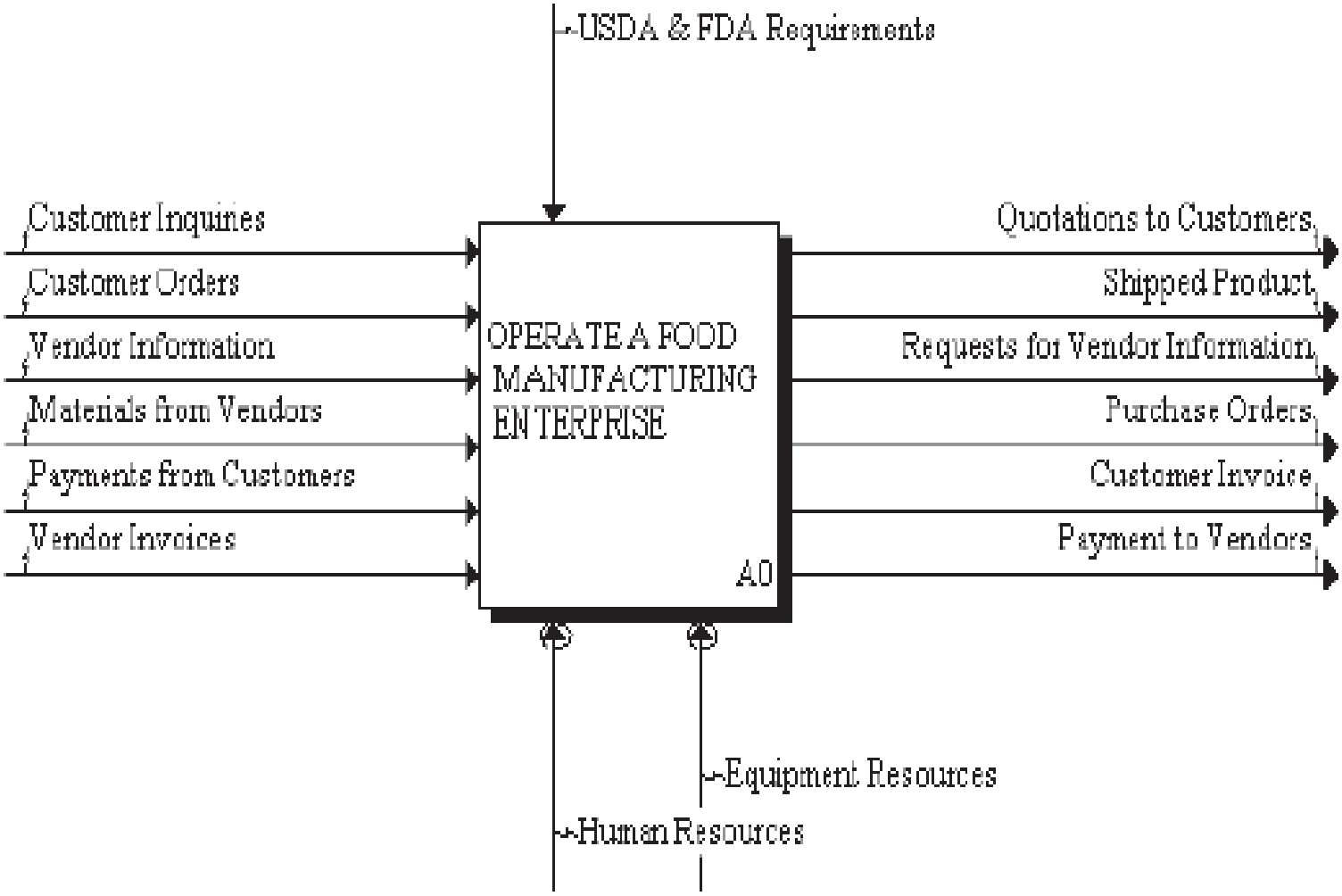
- Functions are related to each other by their material flows and information flows. For example, the output material or information of one activity may provide the input to another activity.

IDEF0 activity

- Relationship among levels in IDEF0 methodology



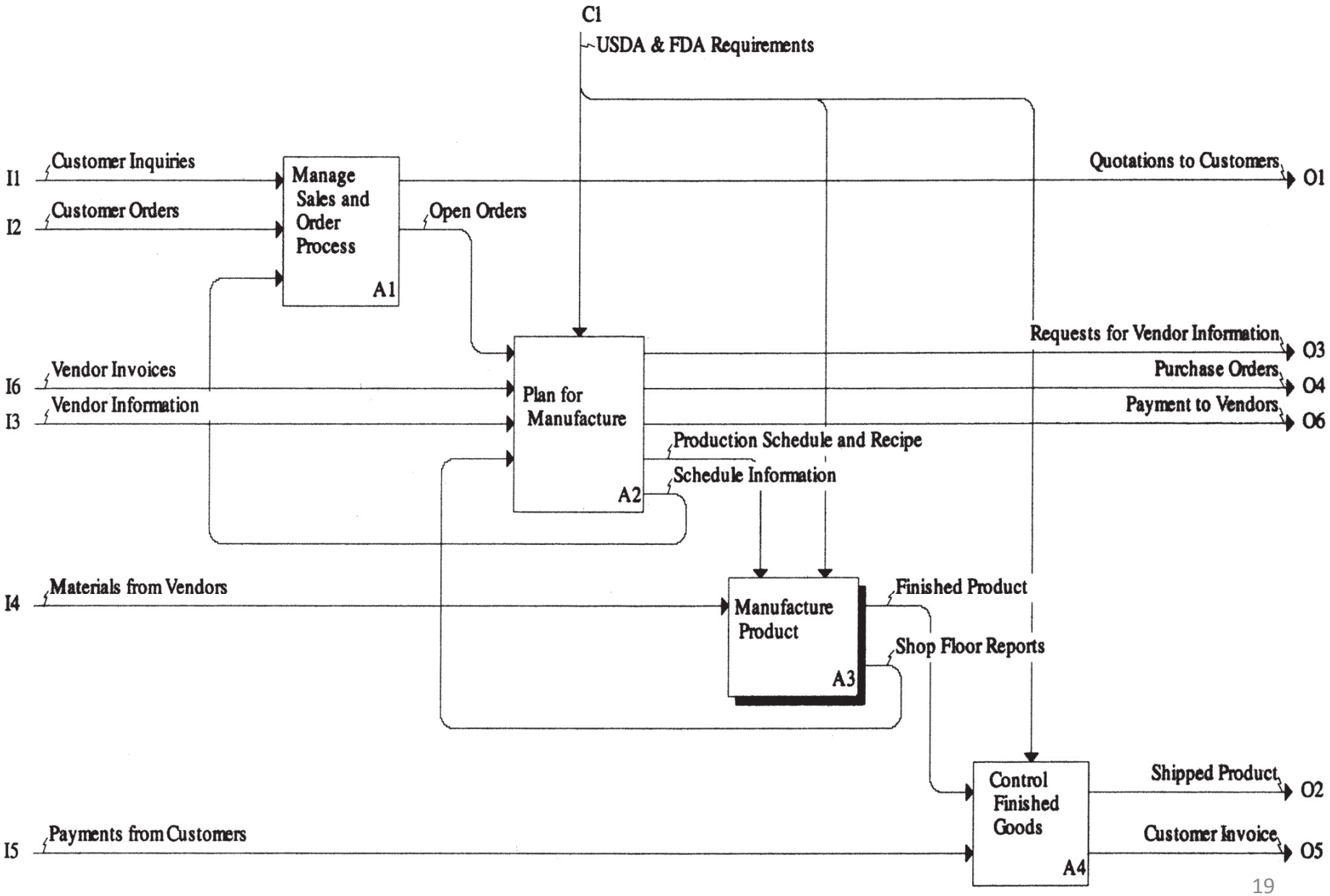
An integrated IDEF0 model of an entire manufacturing enterprise



Elements of the A0 Activity

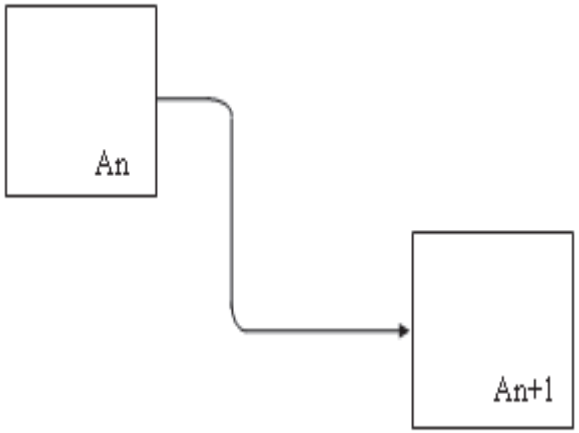
- **Related Inputs and outputs**:
  - Customer inquiries (I)/quotations to customers (O)
  - Customer orders (I)/shipped product (O)
  - Customer invoice (O)/payments from customers (I)
  - Request for vendor information (O)/vendor information (I)
  - Purchase orders (O)/materials from vendors (I)
  - Vendor invoice (I)/payments to vendors (O)

Decomposition of node A0



Decomposition of node A0

- Decomposing node A0 identifies four major activities at the next level:
  - A1: Manage Sales and Orders Process,
  - A2: Plan for Manufacture,
  - A3: Manufacture Product, and
  - A4: Control Finished Goods.



- It is also recommended that, at each level of decomposition, from **three to six** child activities be created from each parent.

Decomposition of node A0

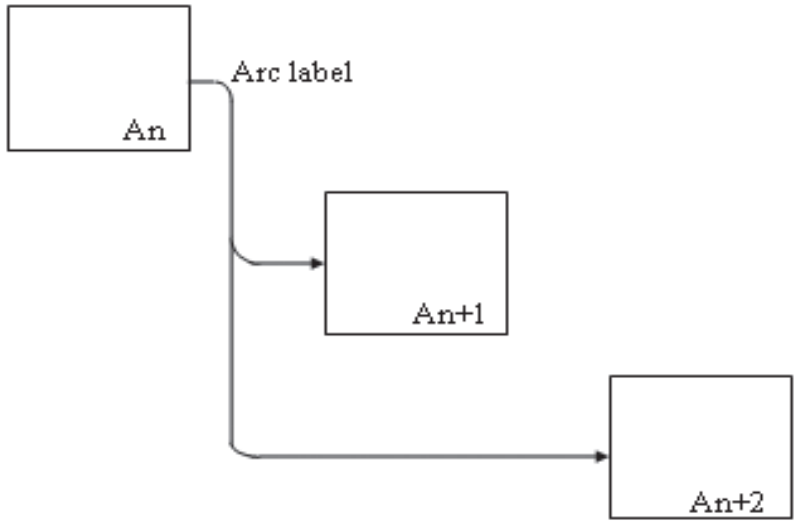
- The breakdown structure of an activity into its main child activities is usually written in an indented list. The following indented list applies at this point:

A0 — Operate a Food Manufacturing Enterprise

- A1 — Manage Sales and Orders Process
- A2 — Plan for Manufacture
- A3 — Manufacture Product
- A4 — Control Finished Goods

Connecting flows between activities

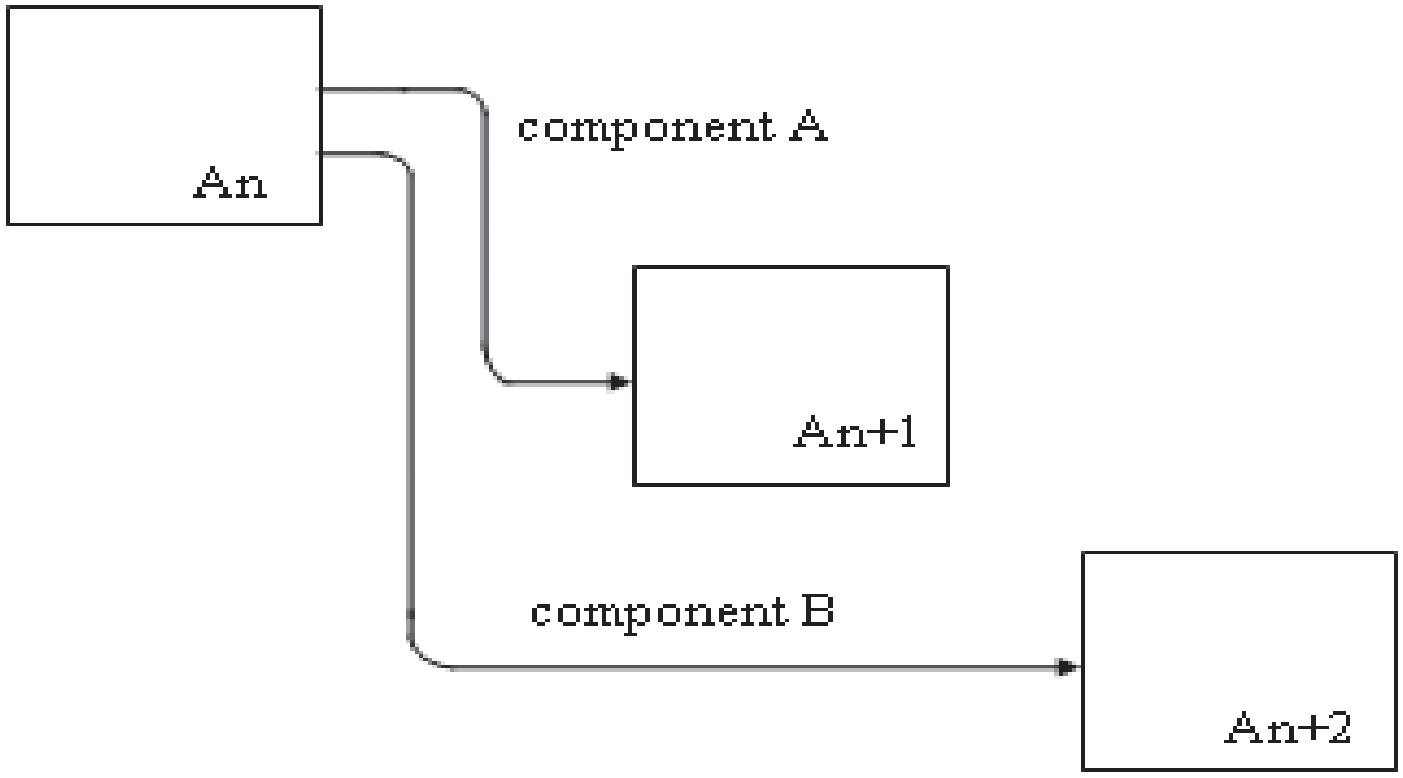
- **Parallelism**: Simultaneous flow to more than one activity



- This is more common with a flow of information than with a flow of physical entities.

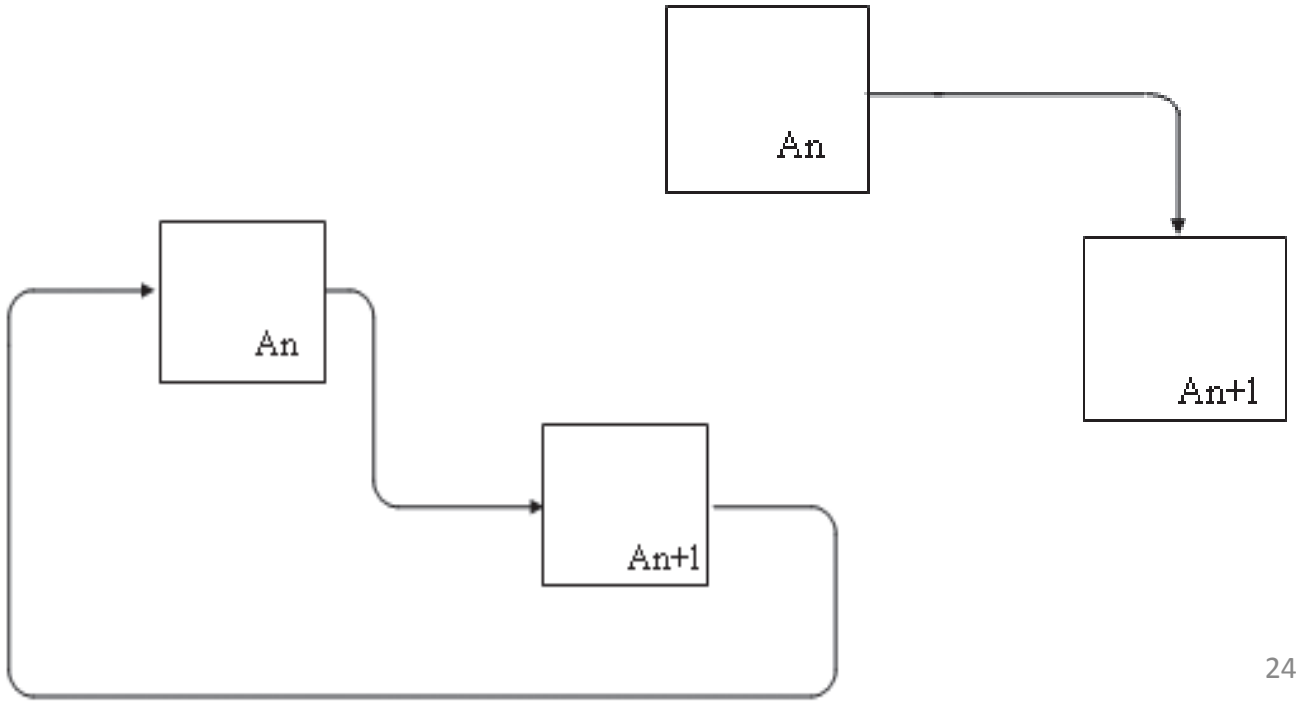
Connecting flows between activities

- Distribution of flows to more than one activity



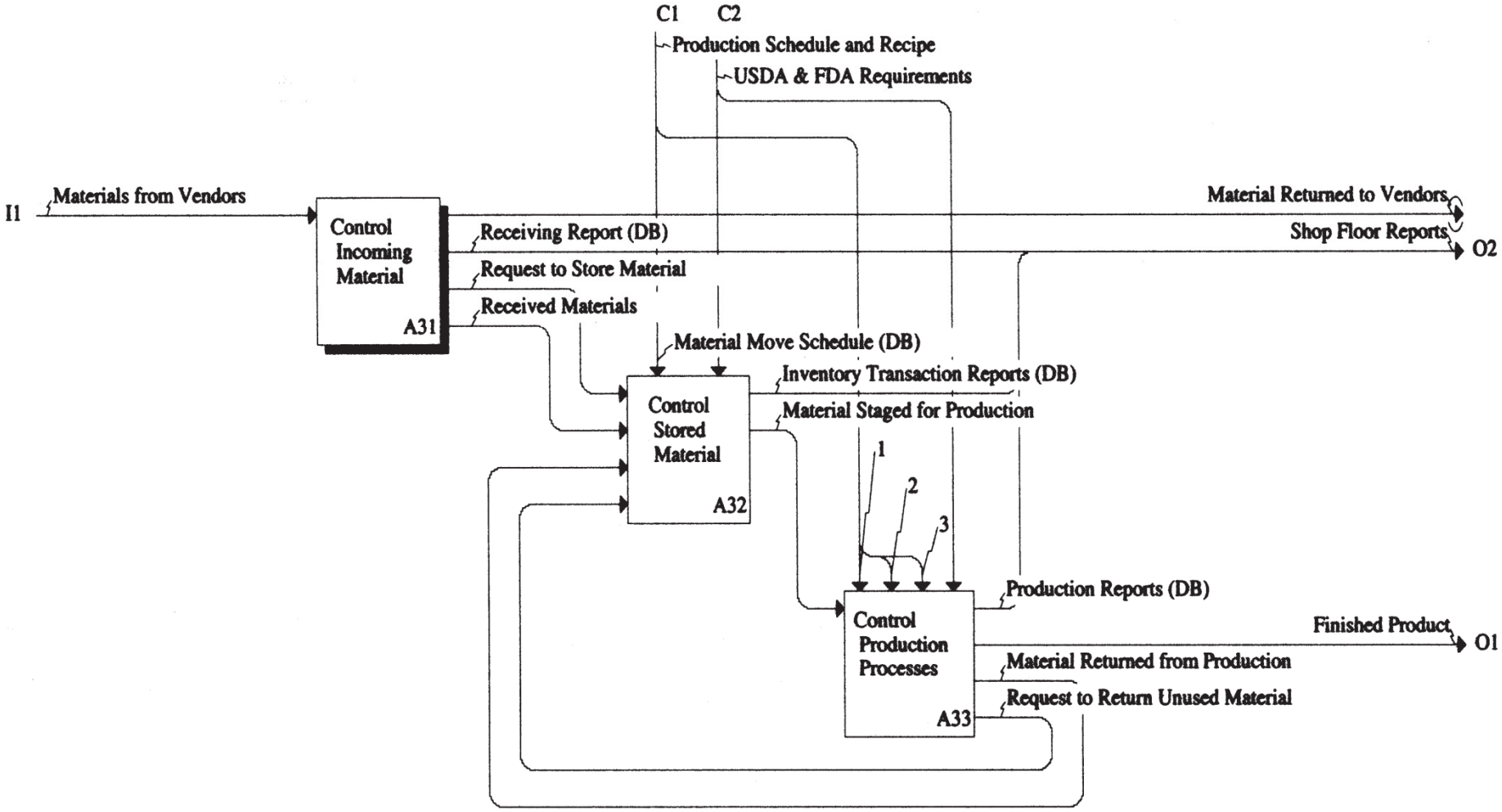
Connecting flows between activities

- One activity can provide inputs, controls, or both to other activities. This is control relationship (production schedule and recipe , as an information tells activity A3 what and how products will be produced on a specific day



- Feedback:

Decomposition of node A3



1 - Retort Processing Information (DB)
2 - Cook Sheet (DB)
3 - Day Production Schedule (DB)

Decomposition of node A3

- The concept of tunneling is important . The output of activity A31, labeled “Material Returned to Vendors.” Note the tunnel on the arrowhead of the arc. A tunnel arrow is used as a convenience. It can represent:

(1) an external arrow that did not appear in the parent diagram (i.e., it has a **hidden source**) or

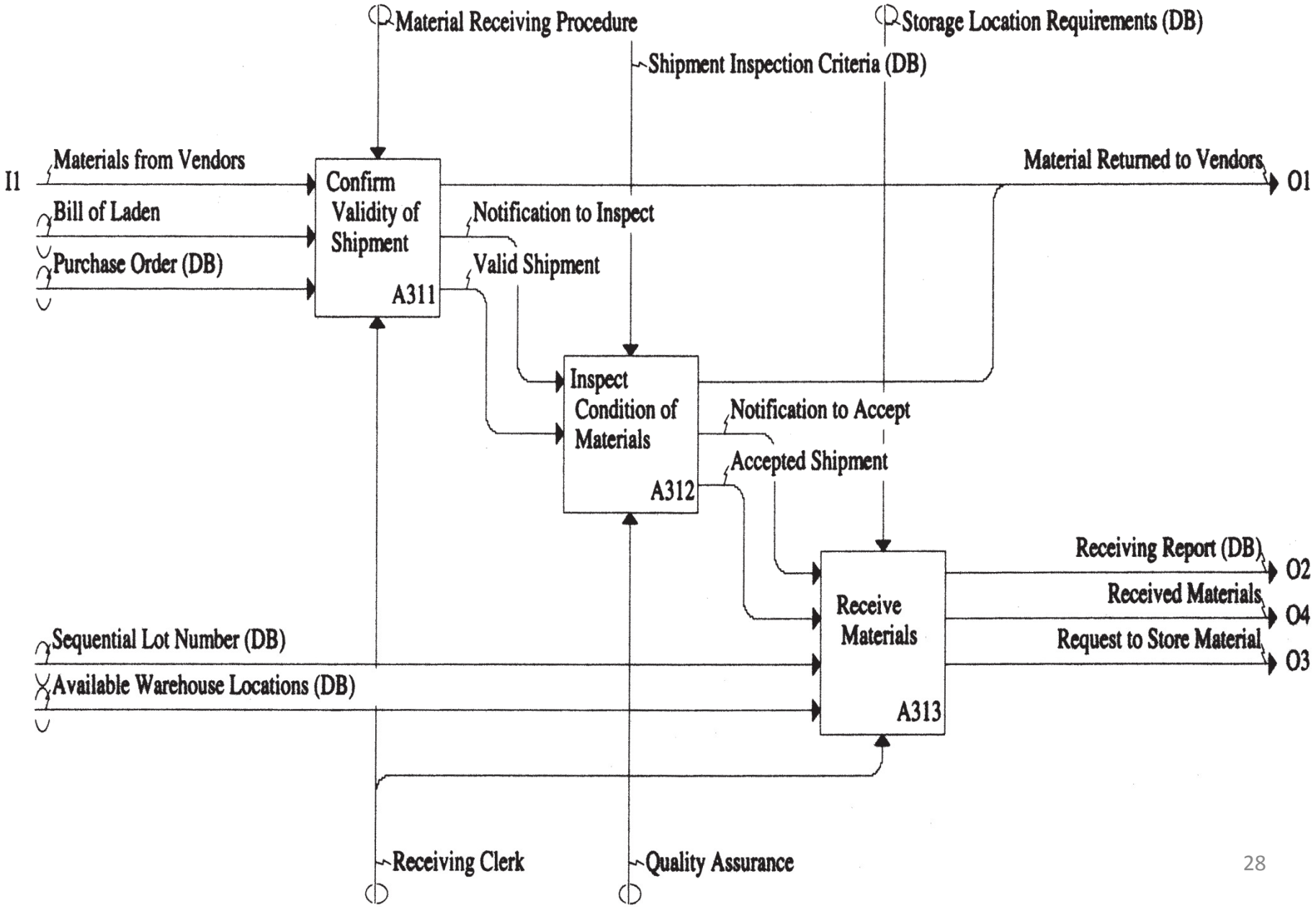
(2) an arrow that goes to another activity but does not appear explicitly on the destination activity (i.e., a **hidden destination**).

- Tunneling is used when it is not convenient to show all inputs, outputs, controls, or mechanisms at every level of the hierarchy.

Decomposition of node A31

A0 — Operate a Food Manufacturing Enterprise
- A1 — Manage Sales and Order Process
- A2 — Plan for Manufacture
- A3 — Manufacture Product
  - A31 — Control Incoming Materials
    - A311 — Confirm Validity of Shipment
    - A312 — Inspect condition of materials
    - A313 — Receive Materials
  - A32 — Control Stored Material
  - A33 — Control Production Processes
- A4 — Control Finished Goods

Decomposition of node A31



Functional/process modeling
Data Flow Diagram (DFD)

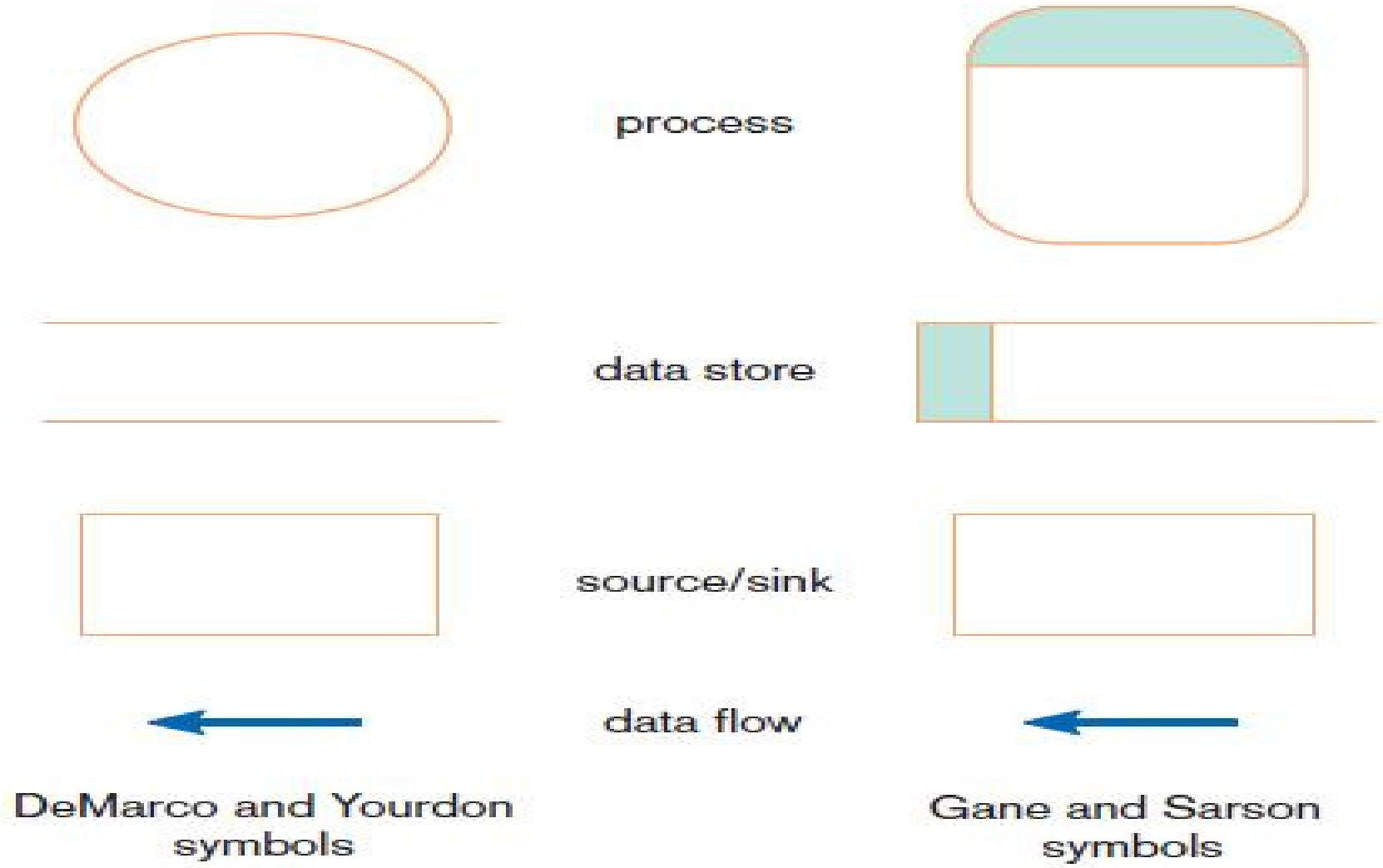
Process/functional Modeling

- Graphically represent the processes that capture, manipulate, store, and distribute data between a system and its environment and among system components.

Data Flow Diagramming

- Useful for depicting purely logical information flows
- DFDs differ from system flowcharts which depict a procedure

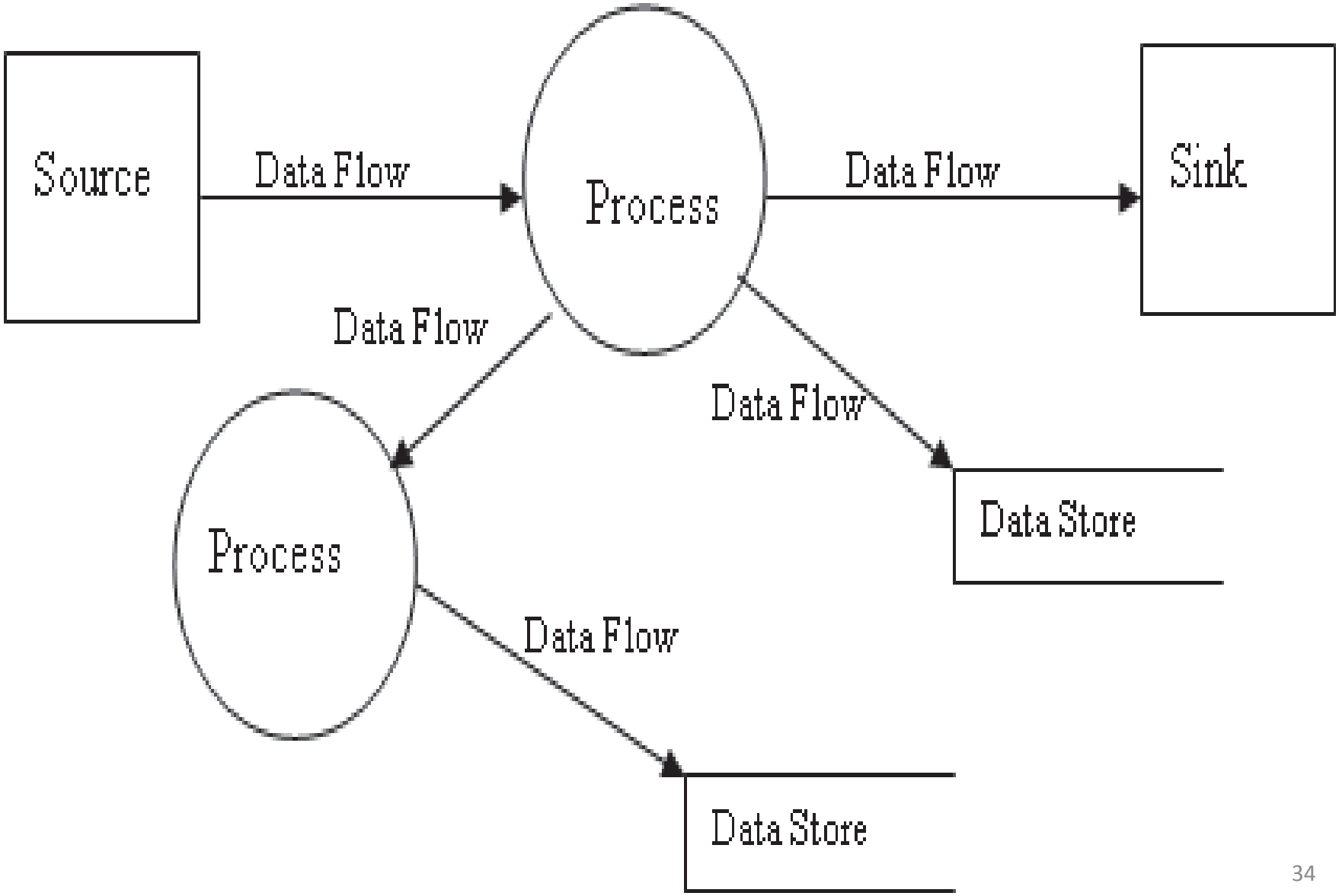
DFD symbols/notation



Components of DFD

- **Process**: work or actions performed on data (inside the system)
- **Data store**: data at rest (inside the system)
- **Source/sink**: external entity that is origin or destination of data (outside the system)
- **Data flow**: arrows depicting movement of data

DFA modeling primitives



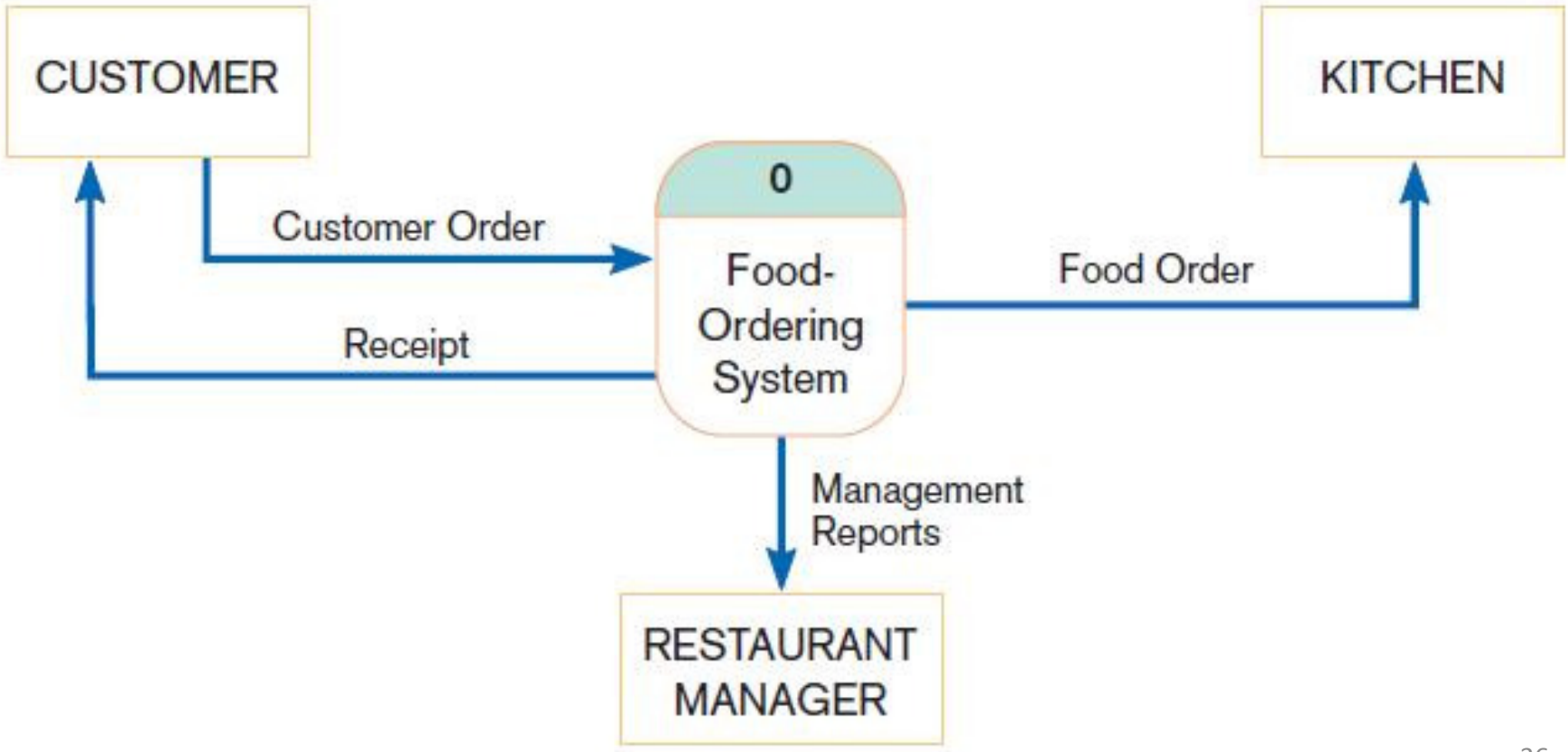
Developing DFDs

- **Context diagram** is an overview of an organizational system that shows:
  - the system boundaries.
  - external entities that interact with the system.
  - major information flows between the entities and the system.

- **Context diagram** is only one process symbol, and no data stores shown

Developing DFD: Context diagram

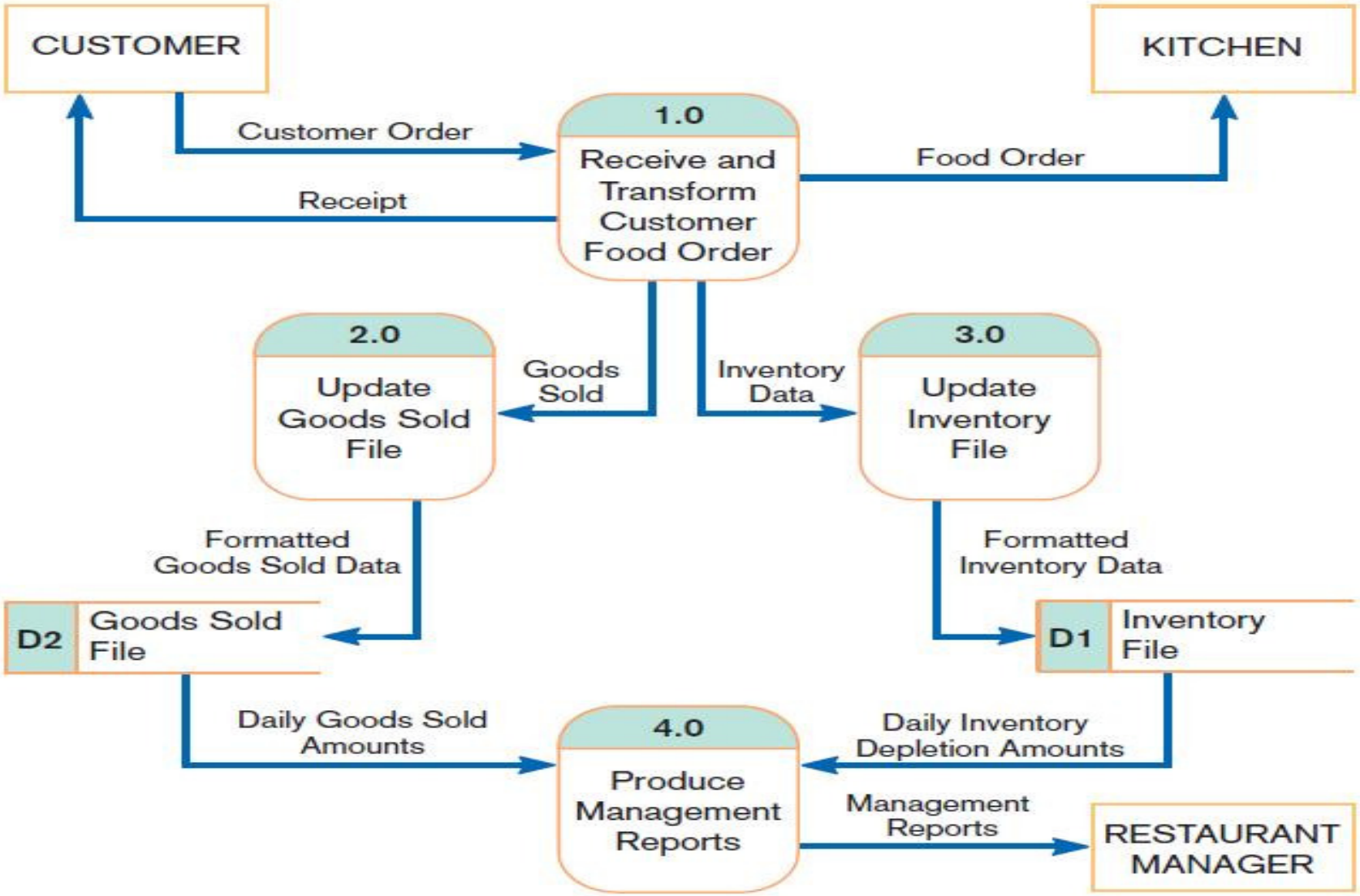
- Context diagram of food ordering system



Developing DFD: Level 0

- **Level-0 diagram** is a data flow diagram that represents a system's major processes, data flows, and data stores at a high level of detail.
  - Processes are labeled 1.0, 2.0, etc. These will be decomposed into more primitive (lower-level) DFDs.

Example level 0 DFD



Data Flow Diagramming Rules

Process:

A. No process can have only outputs. It is making data from nothing (a miracle). If an object has only outputs, then it must be a source.

B. No process can have only inputs (a black hole). If an object has only inputs, then it must be a sink.

C. A process has a verb phrase label.

Data Store:

D. Data cannot move directly from one data store to another data store. Data must be moved by a process.

E. Data cannot move directly from an outside source to a data store. Data must be moved by a process that receives data from the source and places the data into the data store.

F. Data cannot move directly to an outside sink from a data store. Data must be moved by a process.

G. A data store has a noun phrase label.

Source/Sink:

H. Data cannot move directly from a source to a sink. It must be moved by a process if the data are of any concern to our system. Otherwise, the data flow is not shown on the DFD.

I. A source/sink has a noun phrase label.

Data Flow Diagramming Rules - cont.

Data Flow:

J. A data flow has only one direction of flow between symbols. It may flow in both directions between a process and a data store to show a read before an update. The latter is usually indicated, however, by two separate arrows because these happen at different times.

K. A fork in a data flow means that exactly the same data goes from a common location to two or more different processes, data stores, or sources/sinks (this usually indicates different copies of the same data going to different locations).

L. A join in a data flow means that exactly the same data come from any of two or more different processes, data stores, or sources/sinks to a common location.

M. A data flow cannot go directly back to the same process it leaves. There must be at least one other process that handles the data flow, produces some other data flow, and returns the original data flow to the beginning process.

N. A data flow to a data store means update (delete or change).

O. A data flow from a data store means retrieve or use.

P. A data flow has a noun phrase label. More than one data flow noun phrase can appear on a single arrow as long as all of the flows on the same arrow move together as one package.

(*Source:* Adapted from celko, 1987.)

DFDs and IDEF0

- DFD is an alternative to IDEF0 that is widely used in all industries, both in modeling manufacturing and service processes and operations.

Decomposition of DFDs

- **Functional decomposition** is an iterative process of breaking a system description down into finer and finer detail.
  - Creates a set of charts in which one process on a given chart is explained in greater detail on another chart.
  - Continues until no sub-process can logically be broken down any further.

Hierarchic decomposition in DFA

- Data flow diagrams follow the same principles of hierarchic decomposition as IDEF0. The highest level diagram is called the **context diagram**

- The context diagram includes the overall process and the sources and sinks that interact with the overall process

- The context diagram is decomposed into a first-level diagram that shows more details of the process and data flow

- The boundary relationships of the context level are maintained at each successive level of decomposition

- Therefore, data flows from sources and to sinks that appear at the context level also appear at the first level of decomposition

- Decomposition explores greater levels of detail, data stores not represented at the context level may be introduced

Hierarchic decomposition in DFA

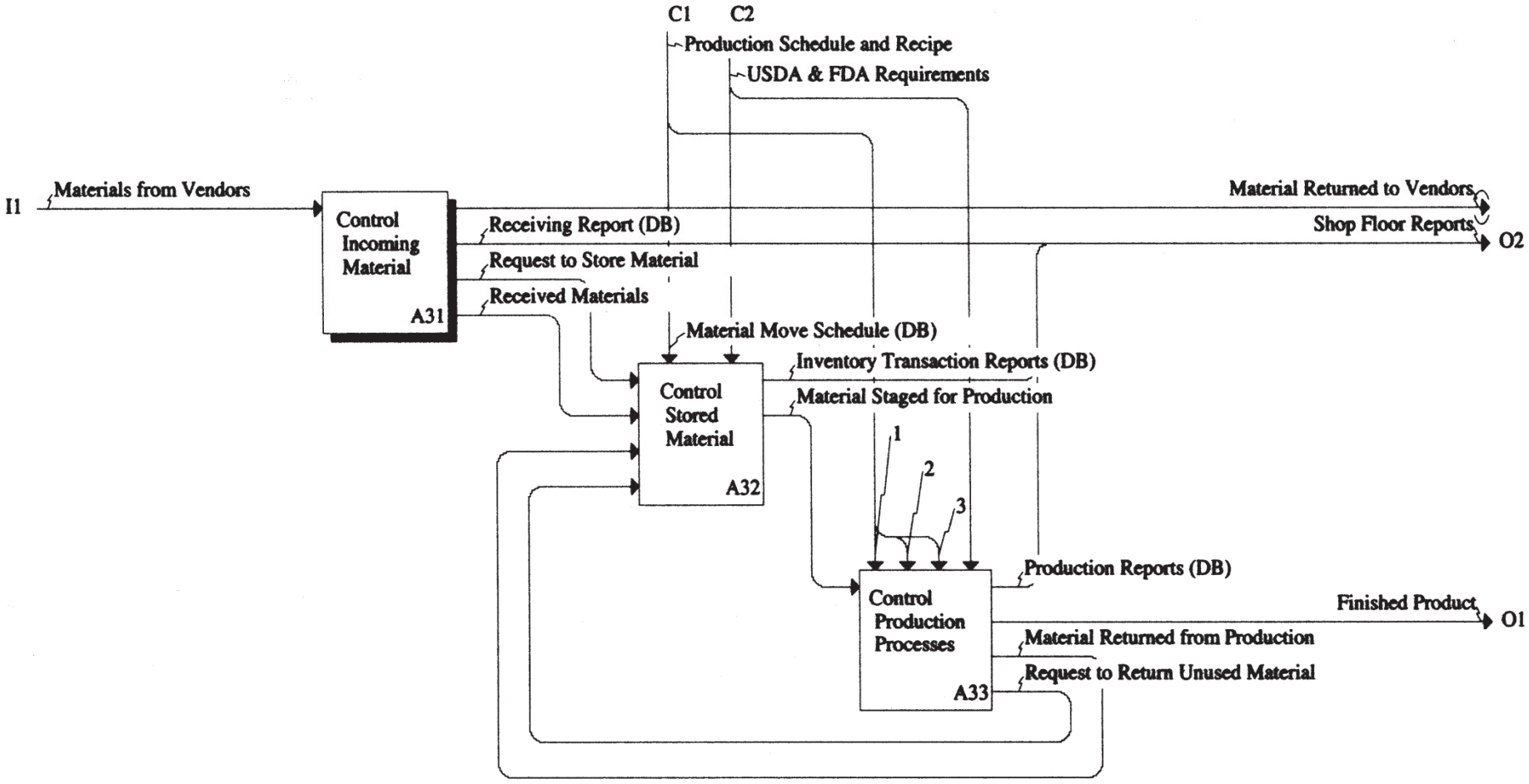
- In general, decomposition should be carried out to the degree necessary for the analyst to understand the details of the functions and data flows

- DFA is widely used in industry. It differs from IDEF0 in that it focuses exclusively on business processes and the information that flows among processes, ignoring material flows, mechanisms, and controls.

Decomposition of DFDs

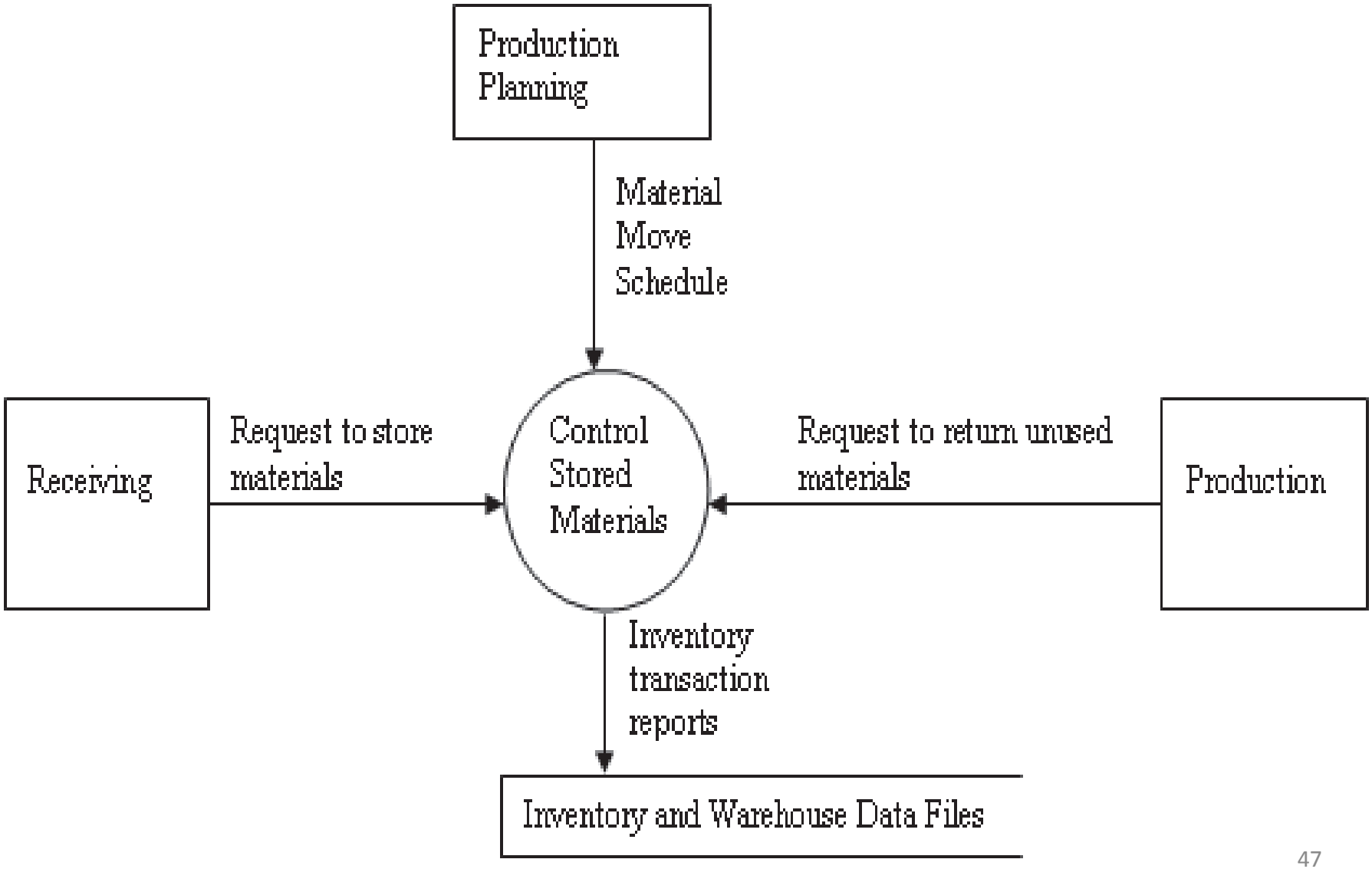
- Primitive DFD is the lowest level of a DFD.
- **Level-1 diagram** results from decomposition of Level-0 diagram.
- **Level-n diagram** is a DFD diagram that is the result of ***n*** nested decompositions from a process on a level-0 diagram.

Hierarchic decomposition illustrated: node A3



1 - Retort Processing Information (DB)
2 - Cook Sheet (DB)
3 - Day Production Schedule (DB)

DFD of node A32



Hierarchic decomposition : node A32

- There are three source entities at the boundary of the system. They are receiving, production planning, and production.
- Receiving is the entity in charge of the process “Control Incoming Material”
- Receiving is a “trigger” محدث for the process “Control Stored Materials” (i.e., it initiates an action in the process when it makes a “request to store materials”)
- The production planning department is the source of another trigger. The trigger to move raw material from the warehouse to work in process is the material move schedule.
- Similarly, a “request to return unused materials” from the production supervisor is another trigger to the process. Raw material that has been moved into production but not used must be returned to storage.
- Finally, the process sends an inventory transaction report to a data store.

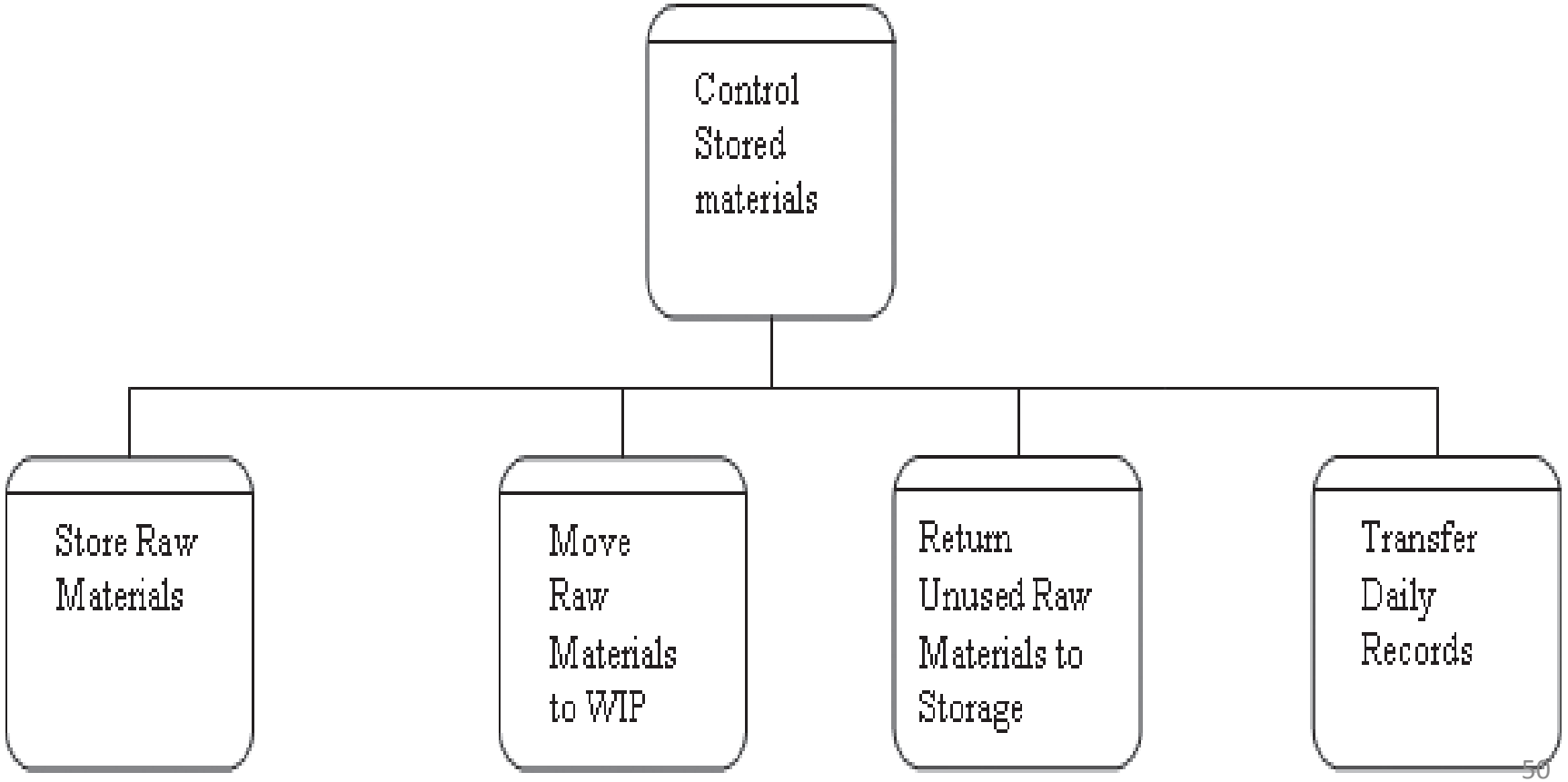
Decomposition of context data flow diagram

- The overall structure of the data flow diagram hierarchy is often shown in a **process hierarchy chart**

- The process hierarchy chart is a series of block diagrams that show the hierarchic relationship among processes that are documented in the data flow diagrams.

Decomposition of context data flow diagram

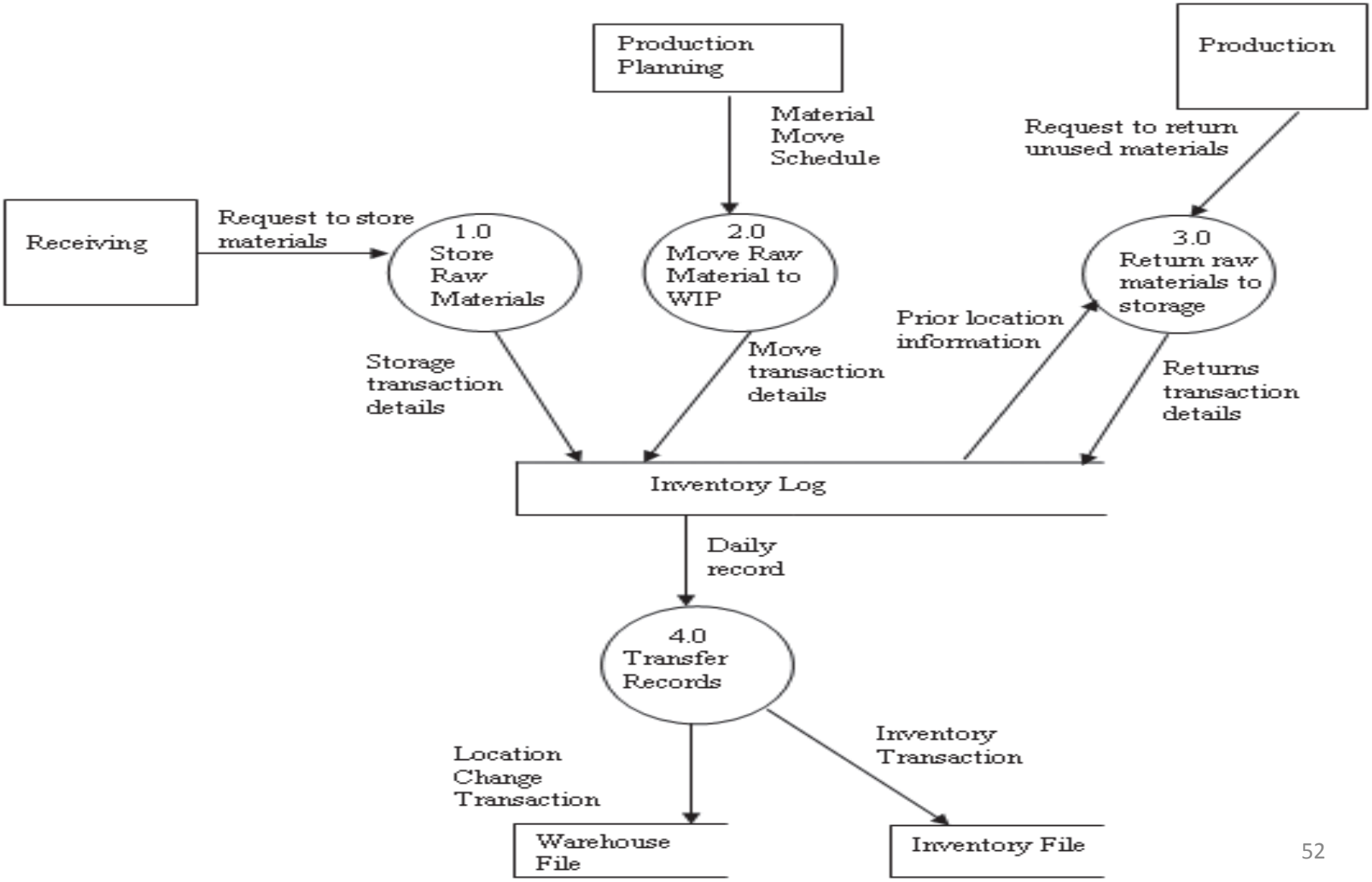
The hierarchic process function:



Decomposition of context data flow diagram

- The context process (Control Stored Materials) is composed of four level-1 processes:
  - Store Raw Materials
  - Move Raw Materials to WIP
  - Return Unused Raw Materials to Storage
  - Transfer Daily Records.

Decomposition of control stored materials: first-level



Description of decomposition of control stored materials

1. ***Store raw materials****: Receiving makes requests to forklift truck drivers to move material* from the loading dock to inventory storage. The driver takes the material to the location. The driver places the material in the location and then records the material, the location used, and the date and time of the transaction in the log.

Description of decomposition of control stored materials

2. **Move raw material to WIP**: the forklift truck driver is given the schedule of material moves from storage to the factory floor. Each time the driver makes a move, raw material inventory is debited and the status of the warehouse location is updated. This is done by indicating a transaction to relieve inventory in the log, recording the material, location, date, and time.

Description of decomposition of control stored materials

3. **Return unused raw material to storage**: Some materials that are brought to the factory floor may be returned if they are not used in When production. Upon request from the production supervisor, the driver takes the material back to storage and logs the credit entry into the log.

Description of decomposition of control stored materials

4. **Transfer records:** The forklift truck driver's inventory log is used as the primary record for updating the warehouse and inventory records. This updating is done at the end of the shift

   Materials management checks for any discrepancies between the receiving report and the actual location of material by comparing the log with the receiving report.